ESA planet search missions -

DARWIN

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- Detect earth-like planets, orbiting other stars.
- Characterize the found planets, including determining the presence of earth-like life.
- Provide a high-resolution imaging for general astrophysics.

DARWIN - An overview

- Mission concepts for space interferometers (’84 – ’92)
- Horizon 2000 (’85) – No interferometry mission
- Interferometry studies (’90, ’92, ’94)
- MOFFIT study (‘96)
- DARWIN proposal (‘96)
- DARWIN concept and feasibility study (’00)
- Search for terrestrial exo-planets defined as high priority action in ESA’s long term plan (2000)
- Technology development and trade-offs
- ESA-NASA Letter of Agreement (LoA) (‘02)
- Reassessment of system level study 2005/6

The problem …

- **Star a million (IR) to a billion (VIS) times brighter than exo-earth, separated by 100 mas**

Compare lighthouse and candle in Madrid separated by 1 m

… viewed from Noordwijk

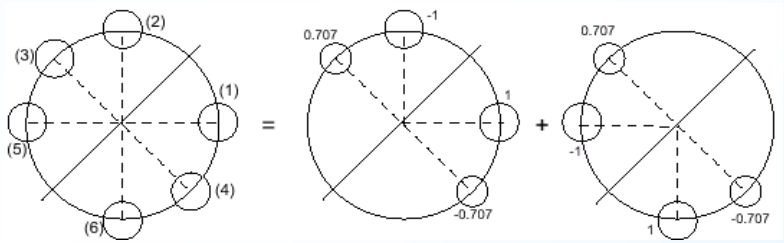
- **Optical nulling of star by 100.000**
  - Optical path difference : 20 nm
  - Telescope pointing : 24 mas
  - Amplitude matching : 1%
  - Wavefront quality : lambda / 2000

- **Science spectral band: 6 –18 micron**
  - Optics temperature: 40 K

DARWIN Concept

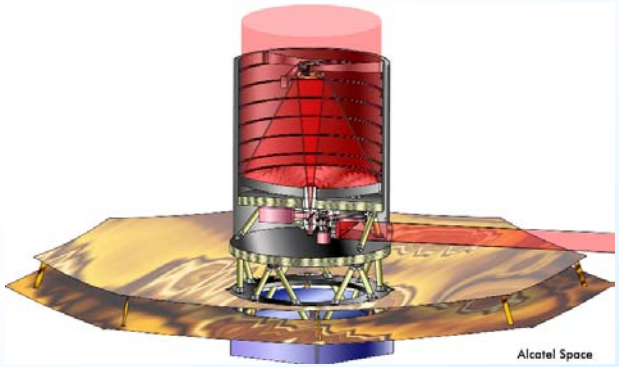
Infrared interferometer

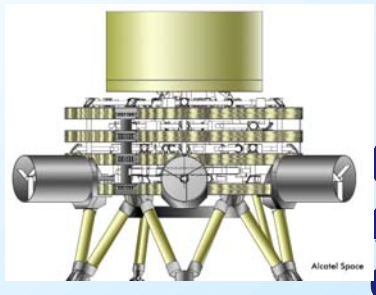
- Multi-aperture : 1.5 m telescopes
- Laurance type configuration
- Wide band spectroscopy



Free-flyer

- Micropropulsion
- Laser & RF metrology





Wavefront filtering

- Enabling technology – relaxes requirement on WF quality

Why free-flying IR interferometer?

- Nulling relaxed by factor 1000 as compared to visual
- Adjustable baseline
- Less demanding than structurally connected
- Less demanding mirror quality (by SMW filtering)
- Formation flying needed for other future missions
- European science community not convinced mission objectives can be achieved visual / reflected light
- Persuing also coronagraph would be expensive

DARWIN Development Programme

Technology Development Programme

Formation Flying

SMART 3
Formation Flying precursor

Interferometry

FINCH -
system simulator formation flying & interferometry

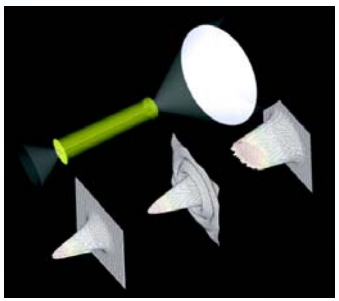
GENIE
stellar nulling interferometry

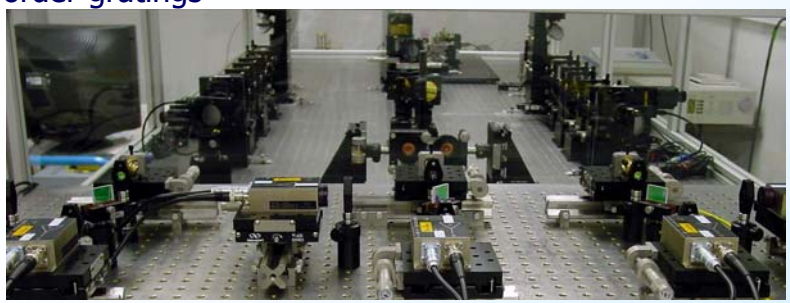
COROT & Eddington
stellar occultations

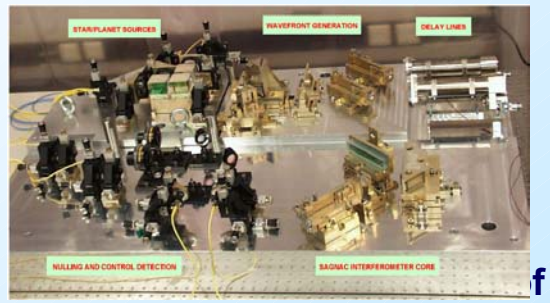
Interferometry

- Optical Delay Line
  - TRP-1: Optical Delay Line
- Achromatic Phase Shifter
  - TRP-1: Achromatic Phase Shifter (breadboarding)
  - GSTP-2: Cryogenic APS
- Single Mode Waveguides
  - TRP-1: Single Mode Waveguides (materials)
  - TRP-2: Advanced Waveguide Coupling Device
- Integrated Optics
  - TRP-1: Integrated optics (materials)
  - TRP-2: Nulling Interferometer in integrated optics
  - TRP-2: Integrated Optics by photo-inscription (explorative)
- Passive Components
  - TRP-2: Dichroics, Beamsplitters, Polarizationsplitters, Coatings, Reproducability
  - GSTP-2: Zero-order gratings

- Nulling breadboards constructed
  - Room temperature (wavelength 1 um)
  - Two arm interferometer
  - Integrated optics (Alcatel)
  - "Bulk" optics (Astrium)
- Next step: DARWIN spectral range
  - GSTP-2: Test harness for high resolution instruments
  - TRP-2: Verification of TIR nulling interferometer
  - Components from various activities
- Next step: Multi-arm interferometer
  - Internal Modulation







Formation Flying -Metrology / Propulsion

- Coarse Metrology
  - TRP-1: Formation Flying RF Subsystem
  - GSTP-2: RF Metrology Subsystem (dual frequency & S-band)
- Optical Metrology
  - TRP-1: High Precision Optical Metrology
  - TRP-1: Fringe Sensor
  - GSTP-2: Cryogenic Fringe Sensor
  - TRP-2: Wavefront tilt sensor
  - TRP-2: Phase Referencing Technology
- Field Emission Electric Propulsion (FEEP)
  - TRP1: Various activities for LISA
- Cold Gas Micro-propulsion
  - TRP2: Components for micro-propulsion

-Formation Flying Control

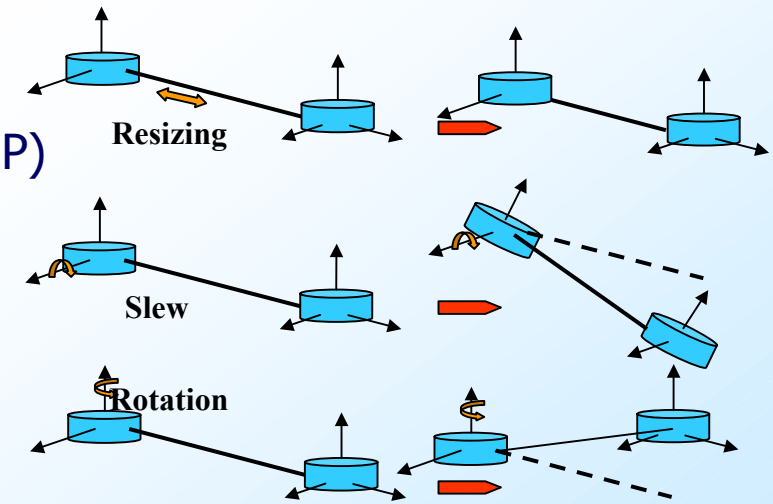
-TRP1: Interferometer Constellation Control (Astrium + Alcatel)

-TRP1: Interferometer Deployment Control

-TRP2: Formation Flying Avionics and Control

-Formation Flying Bread-board

-TRP2: Formation Flying Testbed



Structure, Detectors and Thermal Control

- Structures
  - TRP-1: Solar Array, Sunshield and Radiator
  - TRP-2: Vibration Damping Technology
- Detectors
  - TRP-1: Far Infrared Detector Array (QWIP)
  - TRP-1: Detector Read-Out Electronics
  - GSTP-2: Mid-Infrared Detector
  - TRP-2: Chopping Spectrograph
- Thermal Control
  - TRP-1: Sorption Cooler (second stage 20K to 6K)
  - TRP-2: Vibration Free 18K Cooler (first stage down to 18K)
  - TRP-2: Solid Cryogen Cooler

Architecture Study

IR interferometer architecture study performed by JPL.

Calculation of number of stars that can be surveyed with different configurations.

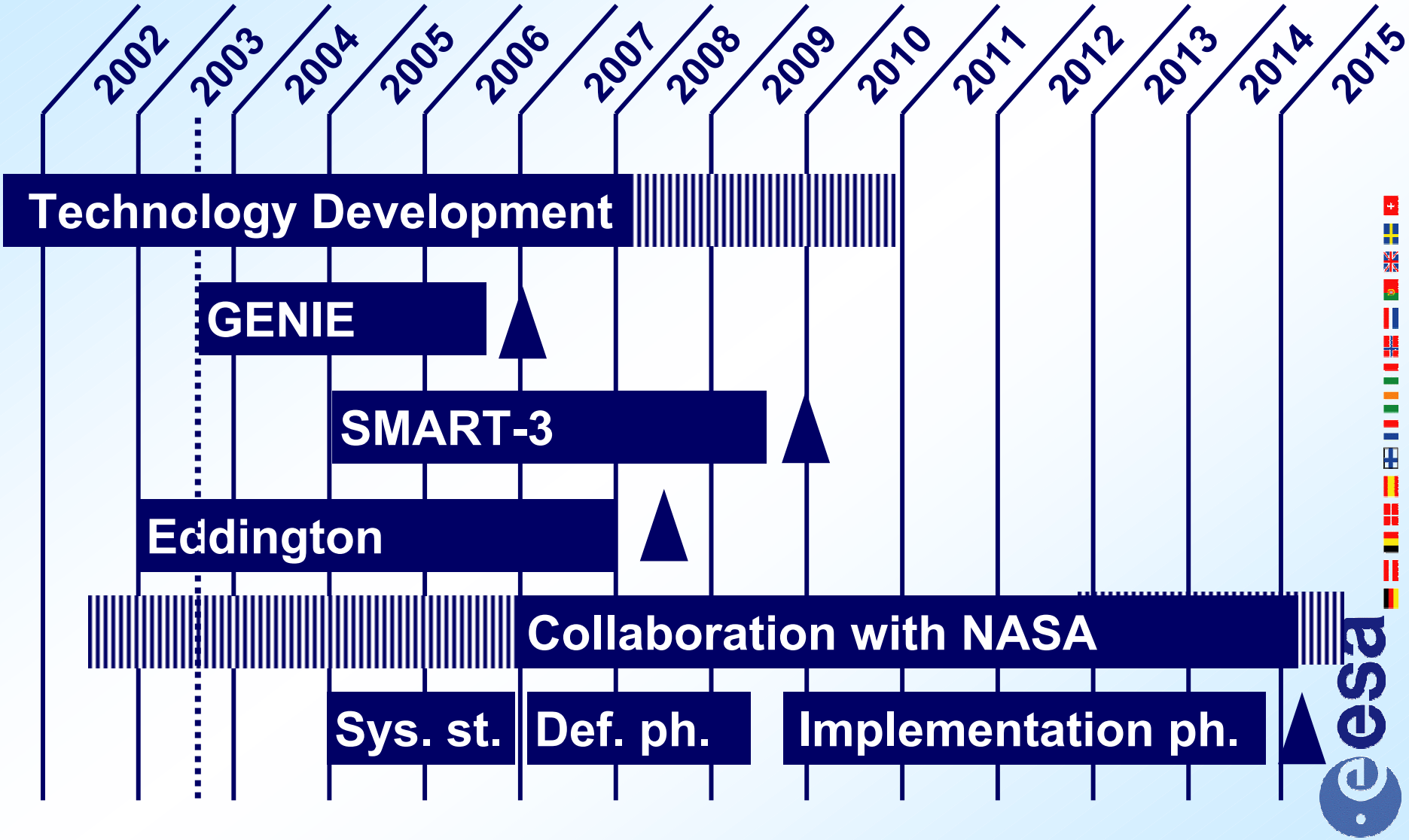
- Preferred config.: Dual Chopped Bracewell (hi-lo)
- Theta-2 suppression sufficient?

ESA performs similar, but independent study.

- expected results: medio January 2004
- different assumptions?
  - star catalogue
  - planet size, wavelengths

Objective: Confirm or identify critical parameters

Schedule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Technology Development
GENIE
SMART-3
Eddington
Collaboration with NASA
Sys. st.
Def. ph.
Implementation ph.